

**A. Introduction**

In this laboratory exercise, your TA will lead you through some simple experiments illustrating the use of laboratory instruments. You will learn how to measure and display voltage waveforms, (created by a waveform generator), on an oscilloscope. You will also hook up a circuit with a resistor and a Light Emitting Diode (LED). Your TA will explain how to set up each instrument as you go. This handout merely serves as a rough guide.

Attendance in this lab is required, but you do not need a lab notebook or parts. The TA will provide parts, and you will hand them in at the end of the lab.

**B. Lab Procedures**

One of the laboratory staff personnel will explain laboratory procedures, including care and use of instruments, checking out equipment, and the procedure for buying parts. By the second week of labs, all students must obtain a parts card and be prepared to purchase parts and build a circuit.

**C. Lab Safety and Instrument Precautions**

After the staff's introductory remarks, you will start using the laboratory instruments. Before you begin, however, please be reassured that we will use only modest voltages, and the cables we will use for the Lissajou figures make it difficult to come in contact with these voltages. Also, the laboratory instruments are robust, and it is quite unlikely that any mistakes you make will cause any harm.

Since almost everyone is new to these instruments, feel free to ask any questions that come to mind. Once you have a circuit working, we encourage you to experiment with the buttons on the instruments. Again, you may do so with the confidence that the instruments are designed to handle virtually all settings.

**D. Lissajou Figures**

A Lissajou figures are similar to the pictures made by a Spirograph<sup>®</sup> toy, but they are made by measuring electrical signals. The circuit we use requires only the use of the instruments on the laboratory benches. We create the circuit by connecting the instruments with cables.

First, check out a "lead kit" from the stockroom. We will use the BNC cables in the lead kit. These cables are black and have a connector on the end with a pin in the center and metal around the outside. There should also be a T connector on top of the

lead kit that allows you to connect two BNC cables together to make a longer cable. We'll need a longer cable before we're through.

Second, following your TA's instructions, find your oscilloscope on the bench, (it has a small screen like a TV set). Connect one end of a BNC cable to the input labeled either "A" or "1". The oscilloscope will make a plot of the voltage versus time that it sees at this input. Connect the other end of the BNC cable to the HP Arbitrary Waveform Generator's "OUT" connector, (located in the lower right-hand corner of the waveform generator's front panel). The waveform generator will create a voltage waveform that changes over time.

Third, turn on both the oscilloscope and the waveform generator. Your TA will explain how to set the output of the waveform generator to be a 100 Hz sinusoid. Then you can press the "Auto" button on the oscilloscope to display a plot of the sinusoid. This voltage is going up and down 100 times a second, and the oscilloscope is able to display this waveform for us to see.

Fourth, connect one end of a BNC cable to the oscilloscope input labeled either "B" or "2". Connect the other end of the BNC cable to the Kronhite waveform generator's "OUT" connector, (again located in the lower right-hand corner of the waveform generator's front panel). Your TA will explain how to set the output of the Kronhite waveform generator to also be a 100 Hz sinusoid. Then you can press the "Auto" button on the oscilloscope again to display a plot of sinusoids from both generators simultaneously.

Fifth, create an x-y plot where, instead of measuring the two voltage waveforms versus time, you let one voltage control the right-left motion of the curve being displayed and you let the other voltage control the up-down motion of the curve being displayed. This is analogous to an Etch-a-Sketch<sup>®</sup> toy where one knob controls the left-right motion of the stylus and the other knob control the up-down motion of the stylus. Now, however, we will let the waveform generators run the knobs, effectively turning them back and forth 100 times a second. To accomplish this task, press the "Main/delayed" button on the oscilloscope front panel. Then look for the menu at the bottom of the display on the oscilloscope, and press the button for "x-y".

If all goes well, you will see an oval that is slowly rotating. At this point you will start experimenting to see what happens when you change the frequency or the waveform shape of each waveform generator's output. Your TA will suggest some experiments to try, and then you will be free to explore. You may generate some very interesting patterns. See if you can determine what pattern will appear before you change the settings on the waveform generators. If both generators output a square wave, for example, what pattern would you expect to see on the oscilloscope? Try it.

## **E. LED Circuit**

After you have experimented with the Lissajou patterns, your TA will hand you a 2 k-ohm resistor and an LED. Using the cables in the lead kit, your TA will show you how to connect the resistor and LED in series. Then you will connect them to the HP Adjustable Power Supply on your bench. The adjustable power supply is like a battery whose voltage may be dialed in. (More precisely, the adjustable power supply is like two batteries in series whose voltages may be dialed in.) The TA will explain how to adjust the voltage to light the LED. The TA will also explain the +, –, and Common connectors on the power supply. You will connect the resistor and LED across the + and Common connectors, then across the Common and – connectors, and finally across the + and – connectors. The TA will explain with circuit diagrams what is happening in each case.

Congratulations. You have built you're first circuits!